STUDIES OF HIGH-TEMPERATURE THERMAL INSULATION SYSTEMS FOR FUEL CELLS

R. Viskanta[1], M. Spinnler[2] and E.R.F. Winter[2]

ABSTRACT. Fuel cells are electrochemical devices that convert chemical energy of a fuel directly to electrical and thermal energy. Fuel cells represent an ambitious emerging technology which has a promise not only to be efficient but which would simultaneously help industrial nations around the world to meet ambitious CO_2 reduction goals. A crucial issue in bringing fuel cell technology to maturity in the future is the need to develop very efficient thermal insulation systems. Effective insulations are required for reducing heat losses to an absolute minimum in order to reach maximum conversion efficiency. The purpose of the paper is to report on an experimental and theoretical study carried out at the Technical University of Munich on high-temperature multilayer thermal insulation systems for application in solid oxide (SOFC) and molten carbonate (MCFC) fuel cells.

Multilayer thermal insulations (MTI) can be characterized by different layers consisting of conventional insulation materials (spacers), such as fibers or microporous powders, that are separated by highly reflective radiation fields. These shields are intended to reduce thermal radiation which can be the dominate mode of heat transfer at high temperatures. The idea of MTI goes hand in hand with the so-called super-insulations which are used at cryogenic temperatures with the difference being that the insulations be comprised of high temperature spacer materials capable of operating up to 1050 °C in fuel cell applications.

Experimental measurements using a specially designed guard-plate installed in a vacuum (thermal) chamber and in an atmospheric apparatus employing silica fibers and microporous spacer materials with and without multiple radiation shields will be described. Instrumentation for measuring incident radiation fluxes and their uniformity, heat transfer rate through the specimen, temperatures and temperature differences across specimen and circulatory coolant water temperature increase will be described and experimental uncertainties will be discussed. Experimental data for four commercially manufactured fibrous filler materials and four microporous materials for temperatures up to 1000 °C will be presented. Predictions based on a model for combined heat transfer by conduction and radiation in absorbing/emitting/scattering porous media will be compared with the experimental data for MTIs with and without shields. Improvements in thermal performance of the latter over the former will be discussed.